STRUCTURAL HD-PE PIPES - THE BASIS FOR PREFABRICATED BUILDINGS AND THEIR SPECIAL OPPORTUNITIES BY COLLECTING POTABLE WATER IN MOUNTAINOUS AREA

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ABSTRACT

In sparsely populated areas a central drinking water supply is not economical. This describes exactly the situation in the mountains. Here, existing sources can be used to supply the people who live in this area. A supply system consist out of pressure pipes, several shafts and storage tanks. The complete system has to be tight, fast to install, easy to operate and must have a long service life. The elements of water supply system are presented. These are usually collecting shafts and storage tanks. The production, the installation and the operation will be described. The basis for all buildings is the structural double wall HD-PE pipe. It has a relative low weight, high ring stiffness and relative low cost. The presented structural double wall HD-PE pipe is made with an solid inner liner, a rectangular reinforcing profile and a final external layer. It can be designed in order to withstand the internal stresses and the external loads. Combined with the characteristics of the material it is ideal for building the collecting shaft and water reservoirs.

It is shown, that for the fabrication of storage tanks and collecting shafts the structural double wall pipes are a vary attractive option regarding the costs and safety during the installation and use.

INTRODUCTION

Requirements of safety in drinking water supply against accidents, contamination, damage to people and property, reliability and hygiene are the most important aspects in the provision life's most essential element: drinking water. Equally important is it to make the correct use of drinking water resources. The local resources should be availed in the individual supply territories.

Transportation of potable water from its source to the user is impossible without conveying units. During the configuration of a supply system attention is being paid to optimising the efficiency of pumps, to the pipe inside diameter and to selecting the proper material. But it is just as important to pay as much attention to all drinking water buildings. They must correspond to the rest of the supply system in terms of functional reliability, safety to the people and durability.

In the drinking water supply the material polyethylene has proven to be successful. Its neutral properties towards flavours are constantly monitored. It has been tested successfully for use with food. It is tasteless and resistant to corrosion. The smooth, poreless texture of its surface reduce the maintenance work. Because of this it makes sense to make the drinking water buildings out of this material as well. With the welding connection of all inlets and outlets in the buildings arises a full plastic system, which provides the best guarantee for a completely tight system.

DESCRIPTION OF THE SITUATION

In mountainous areas, which are only sparsely populated and where houses are a long way away from each other, a central drinking water supply is not possible. Here, the water from existing sources can be collected and a decentralised supply of the attached consumer can be carried out.

The following figure shows a scheme of a decentralised drinking water supply. The water from different sources is collected and transported through pipes to the collecting shafts. Here, a quality and quantity control can be made. After this the water is leading to the storage tank. It is used as a buffer, if necessary a treatment of the water can be made. At last the supply of the attached consumer can be carried out.

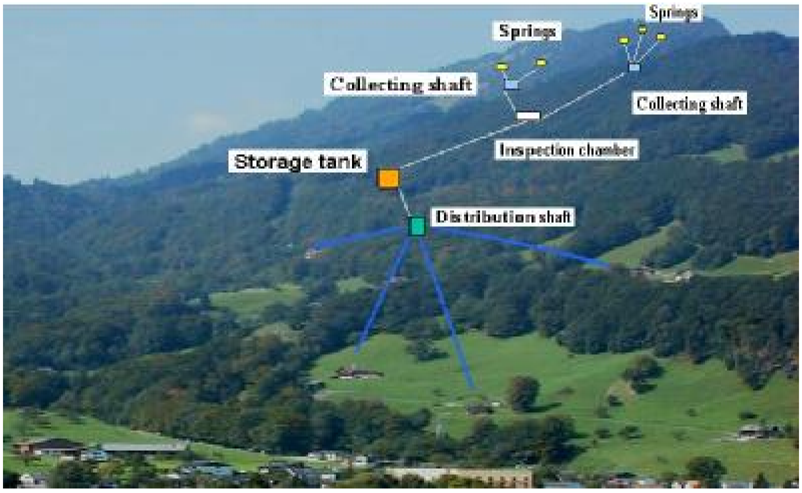

Figure 1: scheme of a decentralised drinking water supply

REQUIREMENTS ON THE BUILDINGS

The buildings must complete the supply system of pressure water pipes, as well as fulfil the requirements of safety and reliability. They're for collecting and storing the potable water. At the same time the tanks and shafts must serve as a connection of the measuring and control technology and as a place where pumps for passing on the drinking water can be put on. For an easy inspection and maintenance the buildings are constructed accessible.

Due to the area, that is only accessible with high difficulties the shafts and tanks should have a low weight, to allow transport by small vehicles or helicopter.

Further requirements are:

- short time for the installation
- low maintenance
- high level of safety
- guaranteed reliability
- economic efficiency

To fulfil these requirements prefabricated buildings are used. Their basis is a structured double wall pipe that is made out of polyethylene.

THE STRUCTURAL HD-PE PIPE WITH LARGE DIAMETER - BASIS FOR THE BUILDINGS

The structural pipes have been designed for land gravity lines. They have a relative low weight, high ring stiffness and relative low cost. The construction of the wall is a combination of a solid liner and a rectangular reinforcing profile. The pipes are produced and quality controlled according to the international standards DIN 16961, pr EN 13476 and ISO 9969. The pipes are spirally wounded on an iron mandrel. The mandrel ensures the inner diameter independent of the wall thickness. The pipes can be delivered from ID 300 to ID 3600. The standard length is 6 m but every needed length can be achieved by welding the pipes in the factory. Figure 2 shows a mandrel with ID 2400 with a solid blue wall.

Figure 2: mandrel with a blue solid wall

The winding technology allows an individual design of the pipes for each project in order to give it the needed characteristics of resistance to internal pressure, external stresses and loads. Thus every ring stiffness can be achieved and pipes for high loaded drain systems and manholes even in large diameters can be produced. Figure 3 shows the possibilities to design the pipes with different profile geometry.

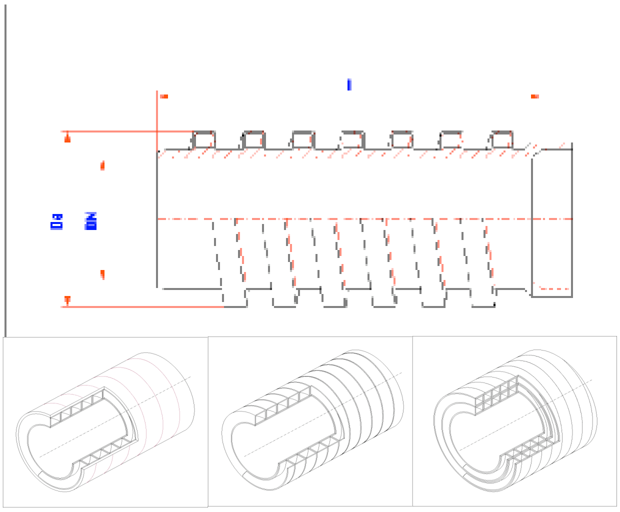

Figure 3: pipe with different profile geometry

Using these pipes for drain systems, every pipe is supplied with a spigot and socket for extrusion welding or with an integrated Electro-fusion socket (Figure 4). The inner surface of these pipes is brightly coloured for comfortable inspection.

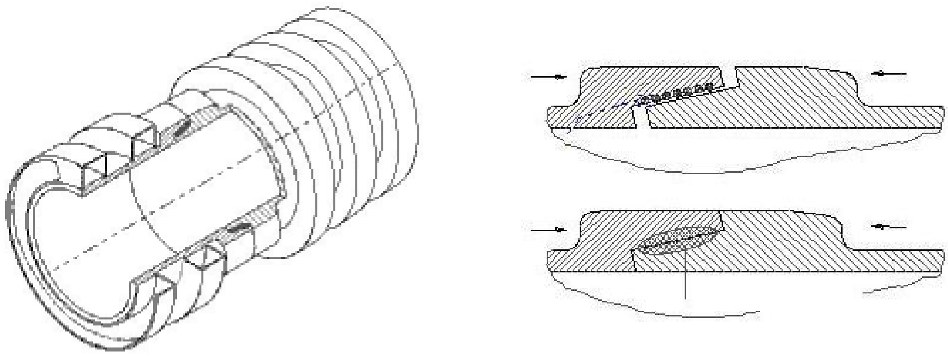

Figure 4: Structured pipe with integrated Electro fusion socket

All pipes that are used for drinking water supply have a blue inner surface. The used material has been authorised for the storage of food and drinking water. The authorisation is made by a test laboratory for testing products used in the water sector which is recognised by the German Association of the Gas- and Water Industry.

For pipes, tanks and shafts which are buried and which have to withstand heavy static or traffic load, the ring stiffness is one of the most important design values. The ring stiffness S_R [kN/m²] is defined as the capability of the pipe to withstand the external pressure or forces. It depends on the moment of inertial of the wall, on the mean radius and the modulus of elasticity.

$$S_R = \frac{E_c \cdot I}{d_m^3}$$

E_c [N/mm²] circumference modulus of the pipe

I	[mm^4/mm]	moment of inertia of the wall
d_m	[mm]	mean diameter

The advantage of these pipes is the high ring stiffness in spite of the low weight. A comparison with a solid pipe makes it obvious:

A typical pipe that is used for storage tanks with an inside diameter of 2000 mm is a combination of a solid inner liner with a rectangular reinforcing profile and a final external layer (see figure 5). This pipe has a long time ring stiffness of $S_{R\ 50years}$ = 0,461 kN/m². To achieve this kind of ring stiffness with a solid pipe a wall thickness of s = 66,24 mm is necessary. Whereas the structural double wall pipe has a weight of w = 218 kg/m, the solid wall pipe has a weight of more then 410 kg/m.

In terms of weight there is an advantage of nearly 200 kg/m when using a structural pipe, which means easier handling during the installation and lower costs for transport.

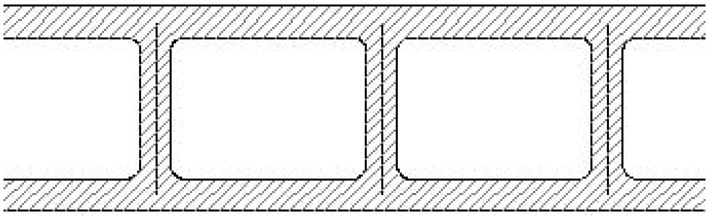

Figure 5: Wall geometry of a structural pipe, that is used for fabrication of shafts and tanks

The total weight of a prefabricated collecting shaft ID 2000 mm is about 880 kg for the complete building. A comparison with rigid building shows the advantage of the weight even clearer. Such a building made of concrete would have a weight of about 12.000 kg (12 tons).

FACTORY CONTROLS AND ASSURANCE OF QUALITY

Only exclusively DIBT (Deutsches Institut für Bautechnik- German institute for civil technique) approved materials are used. When purchasing the raw material HENZE routinely requires a manufacturer's test report.
Upon receiving the material, tests concerning the melting index and density are carried out. After this the material is approved and a prototype of a pipe is produced. This pipe sample is taken for a control test. Melting index and density are once more tested. Additionally the durability of the material under short term tension is checked, a bending test is made and the heat resistance is controlled.
While the model is still tested for long term durability under tension in a wetting agent the material is provisionally approved for production.
The frequency of all tests is in accordance with the external quality control board – HENZE is supervised and controlled by TÜV Rheinland GmbH.
The produced pipes are controlled for the permitted tolerances and other possible faults. After these check-ups we deliver the pipes.As mentioned, the used material is authorised for the storage of food and drinking water.

COLLECTING SHAFTS

In mountainous area the collecting system is composed of the following elements: source, connecting lines and the collecting shaft itself.

The collecting shaft serves as a control station where quality and quantity of the water can be checked before it goes into the reservoir or to the transport lines. At the same time some particles like sand can settle down. For each source there is an intake area and a settlement area which are separated with a scumboard. Each source can separately be measured or can individually be given up. Figure 6 shows a typical collecting shaft from the outside and two possibilities to design the inside of a collecting shaft.

Every collecting shaft has to be divided in an dry chamber and one or several wet chambers. The entrance is always located in the dry chamber, which serves as a base for maintenance and service work. The different water chambers are arranged in such a way, that each source is directed into a separate intake chamber. Thus it is possible to treat them individually.

Figure 6: left: collecting shaft with a conical entrance; right: the inside of collecting shafts

The standard buildings are produced in the inside diameter ID 1200 up to ID 2400 mm. All buildings are constructed using the structural double wall pipes. They have a shaft lid and can be delivered with an conical entrance. Whereas buildings with DN 1200 include only one intake, buildings with DN 2400 can include up to five. A special drainage facilitates the cleaning. The water flow of each source can be measured by installing a rectangular or a triangular-notch thin plate weir.

DRINKING WATER STORAGE TANKS

Drinking water storage tanks serve as buffer stores for fresh water. Thus, variations in consumption can be well-balanced. The size of the storage tank has to be chosen in relation to the amount of fresh water supply, so that a sufficient supply of drinking water can be guaranteed at all times.

As a rule, drinking water storage tanks are manufactured as horizontal models. We differentiate between types with one chamber and those with several chambers. The installations are chosen depending on the surrounding environment. Figure 7 shows a storage tank during the installation. The picture in the middle shows the wall that divides the dry chamber from the storage chamber. On the right side, the dry chamber is shown.

Figure 7: storage tank with a dry chamber and the storage chamber

On account of the geodetical height of many sources, the source water plays a special role in the concept of emergency-water supply. The supply of drinking water can be achieved by gravity, that means no extra energy is needed.

Each storage tank has of course an intake, an overflow, an extraction, and an outlet.
The standard buildings are produced in the inside diameter ID 1800 up to ID 3600 mm. They are constructed using the structural double wall pipes. The front and end wall are made of reinforced PE plates. The entrance is only located into the dry chamber. An exception to this rule are storage tanks for fire-fighting purposes. They are constructed without a dry chamber. The storage volume can be freely chosen. Usually the storage tanks have a volume of 10 m³ to 300 m³

DESIGN AND INSTALLATION

The soil settlements and consolidation require some flexibility of the system, the potential to follow the soil movement. The used numerical calculation methods for pipes and shafts have been verified in practical experiments. Designing plastics pipes or shafts, it is very important to pay attention to make a true description of the product, the soil performance, the way the buildings are installed in the ground and the different types of loading.

The design method, that is used for the design of the pipes, considers the following values:

- Information on building ground, pipe line zone and the main filling. It can have different modulus and the related %-Proctor degree of compaction.
- Information about external loads
- Technology of the installation including the trench excavation
- Height of water level
- Working conditions like temperature or operating pressure

As important as a diligent calculation is the installation. Pipes and shafts perform only as well as they are installed. A proper soil investigation and a definition of the backfill parameters is necessary for the pipe design.

It is well known that the deflection of all flexible pipes and their capability to withstand the external loads are strongly influenced by the installation conditions. Because of the interaction between the pipe and the surrounding soil, the installation should be done properly. Especially the embedment is the most important part of the soil- pipe structure. Regarding the compaction around the pipes, tanks or shafts, it is necessary, that the soil should be of a kind to allow an easy packing into a homogeneous filling and be free from big stones. For this, a frictional material should be used. The compaction of the soil should be homogeneous and evenly distributed. So the deformation can be kept in certain limits. The reason being, apart from the requirements of low strain of the pipe material and of stability against buckling, is the demand for tightness of the joints.

The installation time of the buildings should be as short as possible and includes:

- Supply of all materials
- Making the excavation
- If necessary wrecking of existing buildings
- Preparing the bedding
- Connecting the service pipes
- backfilling
- Surface reinstatement

Our experience shows, that depending on the buildings the installation time can vary between one and four days. Such a short installation time can be achieved, because the buildings are prefabricated in the factory and supplied ready for operation. Only the connection of the service pipes must be made in the field.

Figure 8 shows the installation of a collecting shaft. The transport is being done by helicopter. After preparation of the excavation and the foundation the shaft is positioned and the service pipes are connected. A minimum working space of 0,5 m wide shall be provided. Hereafter the back-filling can be stated. The largest grain should be less then 32 mm. The material is to be filled equally in layers of 20 - 40 cm layerthickness and carefully compacted. If necessary, an extra inlet or outlet can be made at all time during the installation. The last step of the installation is the reinstatement of the surface after the competition of the backfill.

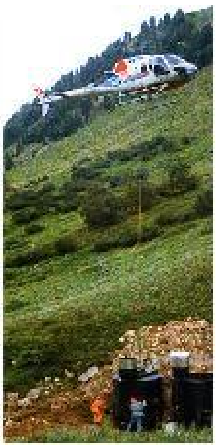


Figure 8: installation of a collecting shaft

Figure 9 shows a small storage tank during the installation and after the reinstatement of the surface. After the trench excavation, the bedding must be prepared. The bedding must ensure an even pressure distribution under the pipe in the surrounding area. According to EN 1610 the bedding type 1 should be chosen. The thickness of the lower bedding shall not be less then 150 mm. After that the compaction of side fill and maim backfill can be started. The initial backfill directly above the tank should be compacted by hand. The side fill and the main backfill are usually compacted with a medium weight vibration stamper. All remarks about the material, layerthickness and working space are valid for the storage tanks as well.

Figure 9: installation of a storage tank: ID 1800 mm and a volume about 10 m³

Because of their low weight, easy handling and the fact that they had been prefabricated, both buildings have been completely installed during two days.

Attention should be given to the loading due to the sloping location. Here special construction measures are necessary. This could be a bench for example.

CONCLUSION

The described structural HDPE pipe is the most important component of buildings like collecting shafts and storage tanks. It has been shown, that a fast and cost-effective installation of an absolute tight, safe and reliable decentralised drinking water supply system can be made in mountainous and sparsely populated areas. As the pipes are designed individually for each project, a highly loaded system even in large diameters can be produced.

LITERATURE

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